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QUARTERMASTER RESEARCH & ENGINEERING COMMAND
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TECHNICAL REPOR
EP-98

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THE USE OF SHORT WAVE ULTRA-VIOLET RAYS FOR THE SEGREGATION OF COMMINGLED SKELETAL REMAINS

QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

AUGUST 1958 NATICK, MASSACHUSETTS

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HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
OFFICE OF THE COMMANDING GENERAL
NATICK, MASSACHUSETTS

Major General Andrew T. McNamara
The Quartermaster General
Washington 25, D. C.

Dear General McNamara:

This report, "The Use of Short Wave Ultra-Violet Rays for the Segregation of Commingled Skeletal Remains," discusses one of the problems often confronting the identification specialist: sorting individual skeletons from mixed burials.

The report describes the reactions of cadaver and archaeological skeletal material to ultra-violet irradiation and evaluates these reactions as a means for separating commingled skeletal remains. Although this method will not differentiate between individuals in all cases, the simplicity of the apparatus required and the speed of resolution make it a valuable adjunct to routine field operations. It represents another tool in the Quartermaster Corps effort to achieve better identification of the Army's war dead.

Sincerely yours,

C. G. Calloway
C. G. CALLOWAY
Major General, USA
Commanding

1 Incl
EP-98

HEADQUARTERS QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report
EP-98

THE USE OF SHORT WAVE ULTRA-VIOLET RAYS FOR THE SEGREGATION OF COMMINGLED SKELETAL REMAINS

Thomas W. McKern, Ph.D.

Anthropology Branch

Project Reference:
AE War Dead Identification

August 1958

Foreword

The identification specialist is often confronted with human skeletal remains that comprise two or more individuals. By using a combination of standard techniques, such as articulation, bilateral and serial symmetry, osteometry, and reconstruction, he may achieve accurate segregation after long and careful analysis. As a part of the Quartermaster Corps research program to improve present identification techniques, as well as to devise new methodology for the identification of American war dead, the present study describes and evaluates a fast and simple test for sorting individual remains from mixed burials.

Based on the reaction of bone to ultra-violet irradiation, this report suggests that individual color differences may be used to segregate commingled skeletal remains, either as a primary technique or as a supplement to present methods.

AUSTIN HENSCHEL, Ph.D.
Chief
Environmental Protection Research Division

Approved:

CARL L. WHITNEY, Lt Colonel, QMC
Commanding Officer
QM R and E Center Laboratories

A. STUART HUNTER, Ph.D.
Scientific Director
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Abstract

When bone surfaces are exposed to short wave ultra-violet irradiation, most of them reflect a variety of colors. The wide range of color emission, as well as the fixed relationship of these colors to the substances that emit them, is justification for attempting to apply these qualities to the segregation of commingled skeletal remains.

After demonstrations of the results of ultra-violet exposure on a large sample of skeletal material, it is suggested that short wave ultra-violet lamps can be used in certain instances for the accurate sorting of commingled remains.

THE USE OF SHORT WAVE ULTRA-VIOLET RAYS FOR
THE SEGREGATION OF COMMINGLED SKELETAL REMAINS

1. Introduction

Ultra-violet rays have a useful property which depends on the power possessed by certain substances to absorb them and emit or re-emit radiations visible to the human eye within the relatively narrow ultra-violet region. When this emission phenomenon lasts only during the period of excitation, it is known as fluorescence and usually results from the simplest form of exposure.

Many substances, both inorganic and organic, fluoresce under ultra-violet irradiation and may be identified by their characteristic colors. For example, mineralogists and petrologists have long used ultra-violet sources to detect the presence of various minerals. Calcites fluoresce red to violet, fluorites show up as red specks, hydrocarbons are yellow, and uranium is green (Radley and Grant, 1954). This same procedure has been employed by medical diagnosticians who can identify certain animal tissues by their colors. Fatty tissues generally fluoresce a strong bluish color, thyroid is reddish, and the pancreas a brown-yellow (Dake, 1942). The more compact the tissue, the stronger is its fluorescence, thus, tendon fluoresces more than muscle, and bone has a still brighter fluorescence. Bone fluorescence is usually whitish with an occasional yellowish cast. However, bone altered by disease, burning, or decalcification may show changes in fluorescence (Hoshijima, 1933).

Because of these known color changes in the fluorescence of bone and the quality of fluorescing substances to emit characteristic colors, the present investigation was made. This report will describe and evaluate the use of ultra-violet irradiation on cadaver and archaeological bone as a means for segregating commingled skeletal remains.

2. Materials and methods

To insure a complete coverage of ultra-violet activity, the bone samples used for the present investigation had to represent different geographical areas, racial groups, skeletal age groups, chronological horizons, both sexes, and varying stages of decomposition. Access to the extensive skeletal collection housed in the U.S. National Museum was of great assistance in meeting these criteria. Thus, the sample included specimens from many parts of the world (eight areas of the United States, Alaska, Peru, Patagonia, Japan, China, Phillippines, Russia, Iraq, Palestine, Egypt, Italy, Germany, Sweden, and Ireland) and six racial groups (Caucasoid, Mongoloid, American Indian, Ainu, Negroid, and Neanderthal*).

Most skeletal age groups were represented (from fetal to adult specimens) and both male and female remains were used when available. The bone samples were completely skeletonized and included fairly recent cadaver remains (Huntington collection, see sect.5e), as well as archaeological material dating from the middle 17th century A.D. back to approximately 40,000 years B.C.

All skeletal material was exposed, under varying conditions, to a portable ultra-violet light (2537 angstrom units).

3. Range of color

Under the ultra-violet lamp, the range of colors emanating from most of the bone surfaces was surprisingly wide, including varying shades of red, orange, yellow, green, blue, purple, and brown.

a. Cadaver material

Most cadaver bone emitted a white, pale yellow, or light green fluorescence, especially from the shafts of the long bones and the flat surfaces of the other skeletal members. On many of these bones, light blue, non-fluorescent spots appeared on the areas of articulation. Paired cadaver humeri exhibited equal color intensities as well as similar color patterning, e.g., the patterns of light blue spots were approximately the same for both right and left bones. There seemed to be no distinguishable color or pattern differences between the sexes or racial groups.

b. Archaeological material

The color range for archaeological material was much more varied. For example, bones from Illinois were reddish-purple, from Egypt, yellow-brown, and from Palestine, pink. For the most part, bleached bones from Japan and Peru showed no fluorescence or color reflectance. In some cases, slight shadings of blue could be detected; this was probably where bleaching was not complete.

* The Neanderthal material consisted of long bone fragments from Shanidar Cave, Iraq.

4. Sources of color

Before the problem of segregation is considered, it might be well to point out some of the known sources for the color seen under ultra-violet irradiation. Generally, these sources may be classified as fluorescence and reflected light.

a. Fluorescence

Fluorescence accounts for most of the color radiation seen in bone. The ultra-violet rays excite certain organic elements, (e.g., organic fat) which in turn fluoresce (Dake, 1942). Thus, the radiated color is directly related to the elements present on the bone surfaces. Blending with or sometimes completely overshadowing the fluorescence of organic constituents are inorganic impurities which may be introduced to the bone surfaces from the surrounding environment. For example, the burial of human remains usually starts a variety of chemical interactions between the bone and its burial environment which may add a number of inorganic substances to the bone surfaces, all emitting their own characteristic color patterns (see sect. 1).*

Two simple experiments were performed to demonstrate the importance of surface contamination to color emission. First, a small portion of the surface area of a clavicle (archaeological), which radiated reddish-purple under the ultra-violet lamp, was scraped with a sharp knife. Placed under the ultra-violet lamp, this scraped area was a yellowish-white and showed no trace of reddish-purple. Secondly, small amounts of soil with a high calcium content were rubbed into the surfaces of fresh cadaver bone until - under daylight conditions all visible soil traces had disappeared. Before this application, under ultra-violet exposure, the cadaver bone had demonstrated only a whitish fluorescence. After application, under ultra violet exposure the rubbed areas were blue.

b. Reflected light

Although a majority of the ultra-violet rays are absorbed by the bone surface, a certain percentage which varies depending on the condition of the bone is reflected back. This reflected blue light (blue because of the blue filter used in the ultra-violet source) may be great enough to completely cloak low levels of organic or inorganic fluorescence, or it may merely blend with that of the fluorescing substances

* Actually, this reaction is one of replacement (fossilization) in which organic elements are replaced by inorganic. Studies have shown that some of the organic constituents of bone are more slowly lost or replaced than others. For example, certain amino acids have been identified in bones of great archaeological age (Ezra and Cook, 1957 and Abelson, 1957).

To summarize:- the visible radiation seen under ultra-violet exposure cannot be identified as solely bone fluorescence, but represents a combination of:1) the fluorescence of organic substances, 2) the fluorescence of variable quantities of mineral substances introduced to the bone surfaces from the external environment, and 3) the reflected blue filter color of the ultraviolet source.

5. Segregation of commingled remains

Samples of mixed skeletal remains were exposed to ultraviolet irradiation to test the suitability of this method for identification. The samples ranged from mixed ossuary material (from a number of archaeological sites) and single burials to cadaver bone in varying stages of decomposition. Each sample was exposed to short wave ultra-violet rays and sorting of individuals was attempted solely on the basis of color differences. The following examples illustrate the general range of results.

a. Virginia ossuary

The material from this ossuary was all from the same pit and represented three individuals. The bones were extremely friable and fragmented. Under the ultra-violet lamp, the bones became a dappled pink and slight shade differences between bones were apparent. However, positive segregation of individual skeletons based on these shading differences was not feasible.

b. Woodruff ossuary, Kansas

Three burials in which bone duplications were found were exposed to ultra-violet irradiation. Exposure produced red, purple and yellow combinations, and it was fairly easy to distinguish and segregate the extra bones from the three burials. However, mixed fetal remains from a single burial could not be differentiated by color alone.

c. Two Illinois burials from adjoining counties (Calhoun and Jersey).

Both burials were complete and came from approximately the same type of soil. Under ultra violet exposure, all bone surfaces appeared reddish-blue but differences in color shading between burials made accurate segregation possible. It was found that shading differences are not immediately noticeable but are detectable after the bone has been exposed for approximately 30 seconds. This delay may be due to normal visual adaptation or may be connected in some way to the function of the exciting process of the rays.

d. Material from Pachacamac, Peru

This sample consisted of parts of three burials from the same archaeological site in Peru. Ultra-violet exposure produced distinct color differences (Figure 1) and the sorting of individual remains was successfully performed.

e. Mixed cadaver material

The cadaver material for this investigation was selected from the Huntington collection; this collection was started around 1905 and has been periodically enlarged. In most cases, segregation of individual bones was accomplished by observing the color differences as well as the depth and shade of color. Also, in cadaver bone, the color is usually spotty and forms complex patterns (see sect. 3a). Thus, in a mixture of paired humeri, the bones belonging to some individuals were differentiated on the basis of color similarity, while in cases where color differences could not be detected, sorting was done by matching similar patterns of color.

The above tests have shown instances where segregation by ultra-violet irradiation was easily accomplished, either through observed color differences or, as in some of the cadaver material, by means of color patterning. In other cases, differentiation was impossible. Color differences were either not present or not great enough to be relied upon for identification purposes.

It is difficult to evaluate these results in the quantitative terms usually applied to the introduction of new methodology. Because of the many variables influencing the radiant elements of a bone, at any given time, from any given place, it would be meaningless to tabulate the percentages of the successes and failures in the present investigation.

To summarize:- the results indicate that ultra-violet irradiation can be used in some cases to aid in the sorting of mixed skeletal remains. This technique has two distinct advantages over the standard methods of segregation (articulation, bilateral and serial symmetry, osteometry, etc.). First, it is fast. The process of observation and segregation can be accomplished in a matter of seconds. Second, it is simple. The investigator can tell at the moment of exposure whether his efforts will be successful. He sees either distinct and dramatic color differences or undifferentiated uniformity.

6. Summary and conclusions

The present study was initiated for the purposes of describing the reactions of various stages of post-mortem bone to ultra-violet irradiation and to evaluate these reactions in terms of their use as a tool for the segregation of commingled skeletal remains.

A knowledge of the range of color produced by ultra-violet exposure was obtained from bone samples (both archaeological and cadaver) that represented various geographical areas, different racial and skeletal age groups, distinct chronological horizons, and both sexes. A wide range of color, which included most colors in the visible spectrum, was demonstrated.

Based on this wide color range of irradiated bone and on the evidence that most colors are consistent in characterizing the particular substances that emit them, tests were undertaken on commingled bone samples to demonstrate the possibility of segregating individuals by means of color differences. The results showed that in a majority of cases, the sorting of individual remains on the basis of differences in observed color was easily accomplished. This was true for both archaeological and cadaver remains. Moreover, for cadaver remains where color differences could not be detected, segregation was done by observing the similarities of color patterns.

Although it is not possible to render quantitative predictions or probability values from this ultra-violet analysis, the study has demonstrated that when other techniques for the segregation of commingled skeletal remains have failed, short wave ultraviolet irradiation is a possible supplement.

7. Acknowledgements

The author is indebted to Dr. T. D. Stewart and Dr. Clifford Evans of the U. S. National Museum for their assistance and cooperation during the collection of the data.

Special thanks are due Mr. Dorson Linnaberry of the QM R&E Center for his expert help in photographing the irradiated bone samples.

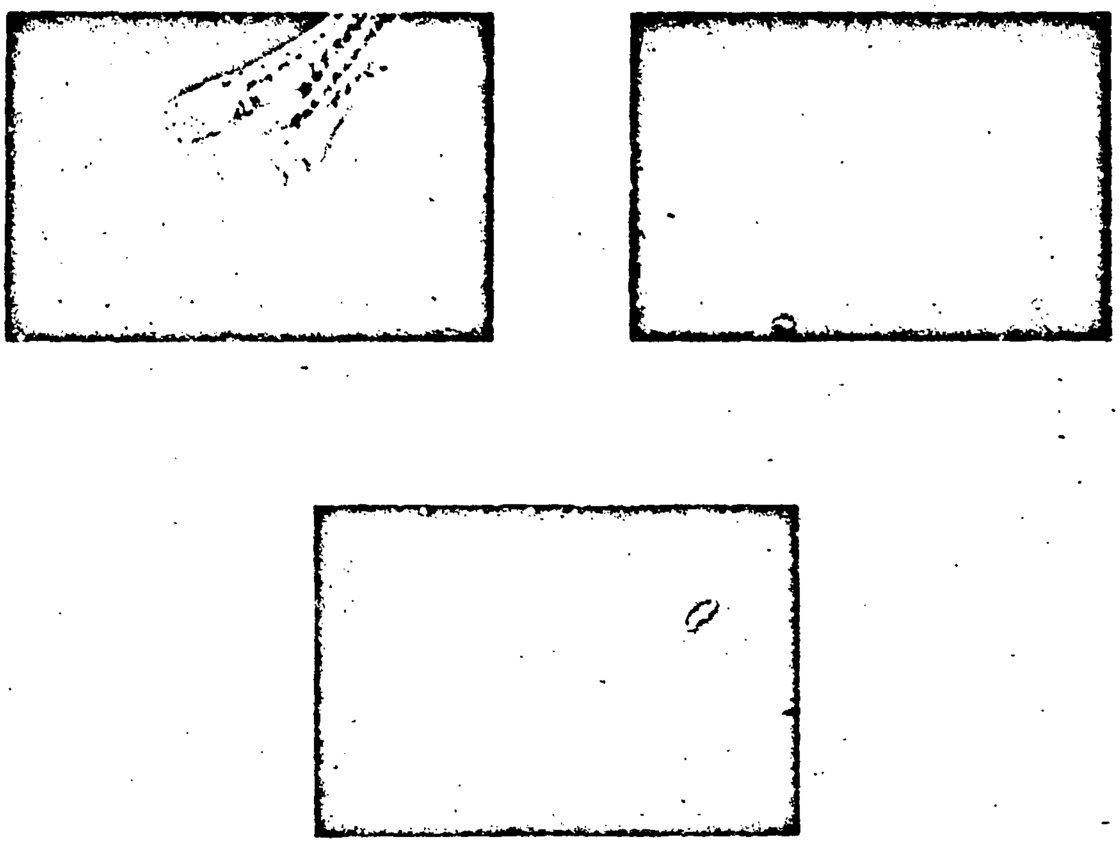

Figure 1. The distal ends of three humeri from Pachacamac, Peru, showing color differences under ultra-violet exposure.

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DEPARTMENT OF THE ARMY
U.S. ARMY SOLDIER SYSTEMS COMMAND
NATICK RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
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REPLY TO
ATTENTION OF

Defense Technical Information Center
ATTN: DTIC-OCQ (Mr. Bill Bush)
8725 John J. Kingman Raod, Suite 0944
Ft. Belvoir, VA 22060-6218

20 July 1998

Dear Mr. Bush,

At the request of Ms. Patti Bremner, Soldier Systems Command Technical Library, I have reviewed the following technical report: ***"The Use of Short Wave Ultra-violet Rays for the Segregation of Commingled Skeletal Remains"***, dated August, 1958, **AD 202 754**, and referenced as Technical Report EP-98, Environmental Protection Research Division, Quartermaster Research & Engineering Center, Natick, Massachusetts.

The above report currently carries a limitation code #2, which restricts its dissemination to government agencies and their contractors. After reviewing TR EP 98, I believe the restriction on distribution is long outdated, and recommend that the distribution code be changed to permit **unlimited distribution**.

Should you have any questions regarding this letter, or any of the Army's past or present anthropology publications from Natick, please feel free to contact me directly at DSN 256-5429.

Sincerely Yours,

Claire C. Gordon

CLAIRE C. GORDON, Ph.D.
Senior Anthropologist
Science & Technology Directorate

Completed
7 Jun 2000
R.W.

cf: Ms. Bremner

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